FACTS

Ministry of the Environment
Ontario

Hon. Jim Bradley
Minister

Rod McLeod
Deputy Minister

ADVERSE EFFECTS OF TRANSBOUNDARY OZONE POLLUTION ON ONTARIO VEGETATION

Visible injury to vegetation which was first reported in the vicinity of Los Angeles in 1944 was one of the earliest indicators of photochemical oxidant air pollution. However, it was not until 1958 that ozone, now recognized as the major component of photochemical smog and one of the most damaging of all air pollutants affecting vegetation, was identified as a direct plant injurious compound in the oxidant complex. The other photochemical oxidants which also are formed through the action of sunlight on reactive hydrocarbons and nitrogen oxides include nitrogen dioxide and the peroxyacylnitrates. Although both the latter pollutants have been scientifically documented as plant injurious compounds, their overall significance with respect to transboundary movement and direct vegetation effects in areas remote from the major industrial centres either is of minor importance or is not yet sufficiently documented to warrant consideration at this time.

Nowhere in Canada has the problem of ozone injury to vegetation been as extensive or as well documented as in the southwestern portion of the province of Ontario. The first indication of transboundary ozone movement across Lake Erie was documented in 1960 following work on the incidence of weather fleck on tobacco and meteorological conditions associated with the build-up of ozone. Since then it has been shown that high ozone levels in Southern Ontario generally are associated with regional, southerly air flows which have passed over numerous urban and industrialized areas of the U.S. Contributing to this transboundary influx of ozone are the numerous urban sources (Metro Toronto, Sarnia, Hamilton, Windsor) which result in higher levels in fairly localized downwind patterns.

Visible foliar injury resulting from exposure to atmospheric ozone usually is apparent either as dark coloured, upper surface lesions, tissue bleaching, or as general yellowing and pre-mature leaf drop. The injury is characteristically interveinal in nature; however, in many species the lesions can become more prevalent along the sides of the larger veins and actually develop over the smaller veinal tissue. The development of systems also is very closely associated with tissue age with leaves ranging from 65-95% of full size being the most sensitive. Young, recently developed leaves are considerably more resistant, as in most cases, are older, fully mature leaves.

AGRICULTURAL CROPS

Foliar responses of crops to natural or artificial exposure with ozone have been well documented and used in the development of species and varietal sensitivity listings and the preparation of short-term predictive dose-response curves for standards setting purposes. However, it is now apparent that this information may not be reliable for estimating the total effect of ozone on final crop productivity (e.g. yield, quality) as more recent studies now indicate that the severity of foliar symptoms is not a consistent indicator of crop growth or

...2

yield effects. In fact, there have been several reports published which demonstrate that ozone related yield reductions have occurred in the absence of any visible leaf symptoms over the duration of the growing season. These types of studies involving the long term assessment of yield or quality parameters under field conditions are complicated by the ubiquity of ozone exposure, the effect of meteorological variables on ozone distribution within crop canopies, and the difficulty in establishing ozone-free control plots. Numerous biotic (pathogen/genetics) and abiotic factors (temperature, humidity, light and soil moisture) within the environment also must be taken into account as each can modify the response of the crop to ozone exposure. The difficulties in dealing with these variables have been partially overcome by recent progress which has been made in the development of field assessment techniques for long term plant growth and productivity effects. These include open top field chambers, pollutant exclusion methods, open air fumigations, ambient air pollutant gradients and the use of chemical protectants.

Since 1970 the Ministry's Phototoxicology Section has conducted extensive foliar injury assessment programs for the major crops (white bean, tomato, potato, tobacco) affected by ozone. These surveys have included the visual examination and microscopic, laboratory confirmation of plant damage at over 1200 Ontario locations since 1970. The degree of foliar injury has varied considerably from year to year reflecting differences in the severity and timing of the ozone episodes relative to the stage of development and sensitivity of the various crops as well as in climatic factors which influence the sensitivity of plant foliage to ozone injury. These studies, together with Ministry funded research projects by scientists at the University of Guelph, and other published scientific information have recently been utilized by Ministry staff in the assessment of the economic impact of ozone on crop production for the following 15 sensitive Ontario crops: white bean, potato, onion, sweet corn, lettuce, radish, spinach, rutabagas, tomato, cucumber, green bean, soybean, grape, wheat and tobacco. This information indicates that Ontario farmers would benefit by up to 29 million dollars annually if Ontario's 1 hour ozone criterion of 80 parts per billion was met in all parts of the Province.

FORESTS

There are many different parameters and limiting factors which must be considered in evaluating and quantifying the effects of ozone on forest trees as compared to agricultural crops. Forest tree species are long-lived, perennial plants that are exposed to ozone repeatedly during the year and over several years and, unlike agricultural crops, are not usually subjected to fertilization, irrigation and pesticide application or other cultural practices that can moderate their response in the field. Assessment of adverse effects of ozone on seedlings or young trees can be evaluated under controlled conditions; however the large size of trees at maturity precludes experimental pollutant exclusion (chamber) studies or the use of protective antioxidant sprays thereby limiting the assessment of yield losses to visual observations of foliar injury, and radial and height growth characteristics of individual trees in the stand. Where growth analysis is undertaken from different stands on the basis of air quality gradients, the data must then be considered in terms of soil and climatic site variation and related to ozone dose information, where available. Another

complicating factor which must be addressed when assessing the overall impact of ozone on forest growth and yield is the process of tree to tree competition and possible alterations in the composition and evolution of the ecosystem under study. In this regard an adverse effect on the growth or survival of one tree species could have either a beneficial or determined effect on the growth or survival of another species thereby increasing or decreasing the total productivity of a mixed forest stand.

On the basis of artificial ozone fumigation exposures, many tree species common to Eastern North America are classified as being susceptible to foliar ozone injury. In Ontario foliar symptoms associated with ozone injury to white ash and Eastern white pine have been observed by MOE staff. There are, however, few available studies which quantify the severity of the ozone foliar symptoms relative to the total annual yield of these or other tree species. The one advantage which is enjoyed by Ontario's forest industry is the fact that ozone levels generally decrease in a south to north direction and thus are lowest in the areas where forests predominate. For this reason forest yield losses due to ambient ozone in northern Ontario are considered to be low when compared to the high yield losses which occur in the agricultural areas in southern Ontario.